



Studies of Signal and Noise Properties of Perpendicular Recording Media

Submitted by

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Abstract

Areal densities of perpendicular hard-disk drives over 500Gb/in² have already been demonstrated, with 1Tb/in² densities being forecasted in the near future. However, at these high areal densities the information bearing units on the magnetic storage medium are magnetically unstable at temperatures expected in hard-disk drives. To extend or bypass this limit, new developments in head and media technologies and understanding of their record, readout and noise performances are necessary.

The aim of this project was to study the record, readout and noise properties of conventional and future perpendicular magnetic recording media, heads and their related technologies. The objectives were therefore to develop a flexible and robust experimental recording platform to test the performance of different heads and media, and develop the necessary readout theory to predict the replay performance.

In line with the project objectives, a high-precision open contact recording tester was developed with 1nm resolution. The open nature of this system allows different heads and media combinations to be tested. A second, closed system was also developed based on a commercial perpendicular hard-drive, modified to serve as a spin-stand to provide signal and noise measurements in practical drive conditions.

The readout process in perpendicular recording was modelled based on the reciprocity principle for a shielded TMR head to study the parameters that affect the readout signal performance, and for comparison with the experimental measurements.

Measured signal roll-off curves showed a practical linear density of 450KFCI for the commercial perpendicular disk medium, and indicated that non-linear effects happen at linear densities approaching 550KFCI. These results were in agreement with the theoretical calculations of the replay process. Two-dimensional readout scans were found have similar or higher resolution than Magnetic Force Microscopy (MFM) images of the same recorded regions – indicating the versatility and precision of the developed contact tester.

Inverse filtering employing the Wiener filter was used to extract the magnetic transition. The extracted transition profiles and transition extents from the replay signals had much higher resolution than MFM images measured for the same transition region, thus showing the applicability of the developed testers for in situ magnetic characterisation.

The developed contact and non-contact testers allowed the investigation of a new proposed recording scheme, Shingled Magnetic Recording (SMR). Measured signal roll-off curves of shingled tracks indicated a rise in the signal amplitude at low densities. At higher linear densities the signal performance was the same as conventionally written tracks with guardbands. It was found that a 30% reduction in track width in SMR, increase the areal density by a factor of 1.58 above that in existing hard drives.

To my parents

Declaration

No portion of the work referred to in the thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

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Preface

Komkrit Chooruang received his B.Eng and M.Eng degrees in Electronic and Electrical Engineering from King Mongkut's Institute of Technology Ladkrabang and Khon Kean University, Thailand in 1999 and 2004 respectively.

He worked as a test engineer for Western Digital and Seagate Technologies, Thailand in 2004 and 2005 respectively. Since then in 2006, he has awarded the Royal Thai Government Scholarship to pursue a Ph.D. degree at University of Exeter. His research involved the development of high precision automated perpendicular recording testers for the experimental investigation of signal and noise characteristics of perpendicular and shingled recording. His interests include the theoretical and experimental evaluation of ultra-high density magnetic recording systems.

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